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THE INFESTATION UNIT

by

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The Infestation Unit.

Thee infestation unit has long been recognized as one of the fundamental problems in insect control. The determination of the character and extent of the insect control unit was listed as the first object of the investigative program of our Ashland conference plan. It is agreed that the value of the data that we are building up is of greatest value in so far as it applies to an intrepretation of the infestation unit and to the possibilities of what can be done with this unit in the way of applying artificial control measures .

Thus far in our Ashland conference pland we work we have made but a very small start on the prbTam. We have only tried out our experiments on one area and several years must elapse before we can expect to have complete results fromtthis. Much data is available however from other sources which has aither a direct or indeirect bearinf on the probelm, and which may be of use to us in planning further work. I am prepared to present only that which been worked out by the Pacific Slope Station. This does not ptetend to be complete or conclusive , but we can use it for whatever it is worth.

By an infestation unit we mean an area in which the amount of infestation will not be materially increased by beetles flying in from outside areas, or decreased by beetles leaving the unit. In other words it is assumed that the factors which influence increase or decrease of beetle populations are operative entirely within the unit itself, and are not affected by population changes outside the unit.

Two factors must be taken into account in setting up an infestation unit: (1) effective boundaries, and (2) the size of the area. For effective boundaries we are forced to rely upon topographic features such as high ridges or breaks in type, which created barries that the beetles are not expected to cross in flight. Failing to find effective barriers the infestation unit must consist of an area so large that the amount infestation which may drift across its borders will not materially increase or decrease the total volume of infestation to an extent that will change trends within the unit.

In tis last analysis the infestation unit is determined byt the flight habits of our Dendroctonus beetles. We have two extremes of opinion on this point. The beetles may fly but a few hundred yards or only far enough to find another tree . Or they may fly many miles. We have no conclusive data to support either position. If it were possible to follow directly the flight of the beetles from the time that they emerge from one tree until they attack another we would soon have this proposition solved, This we have been unable to do. Some very reliable and thorough work along this line was done by Mr.Keen at this station. He succeeded in developing a marking medium which provved to be fairly successful in icentifying the marked beetles after they had been liberated and recovered in fresh logs. In applying the experiment to a field test however the results were negative. Although he marked and liberated approxinately 8000 adult D.Brevicomis beetles none of the stained beetles on a section of timber which had been entirely clear

of infestation, none were recovered. A tree which was subesequently attacked within the same section contained no attacking adults which could be positivley identified as coming fromt the liberation point. Flight experiments have so far prooved inadequate as an approach to this problem, and until they are developed further we will have to depend upon other resources for getting at an intrepretation of the infestation unit.

We started out on control work about ten years ago assuming that we knew within certain limits the extent of the infestation unit. For example it was generally conceeded that it would not be practicable to attempt control work on a single acre of forest land if 1000 acres of infested forests surrounded it. We have enough data to proove this. We can go even further and safely assume that a section of forest will not make a satisfactory unit when it is in the center of a much larger body of infestation. On the other hand we are not willing to admit that the infestation will come in from distances like to or 100 miles, for if that is the case our control problems seem hopeless. Somewhere within these two extremes we will probably find the answer to the infestation unit question.

It will be well to bear in mind however that in looking for a complete infestation unit we are after an ideal which probably does not exist in nature. There are very few bodies of timber in all of our western forests which are completely cut off from other areas by type or topography so that they are entirely free from outside influence. If they do exist the conditions which they involve anre abnormal and not typical of the infestation found in extensive forest areas . The problem of the unit will in all probability be solved if an approxiamte way if it is solved at all.

As we have little actual flight data, our present knowledge of the infestation unitwi depends upon indirect evidence. We may follow this line as far as is consistent and drwn such conclusions as seem logical although they may not be entirely final. We can assume that an area of a given size, with certain specifications as to type and boundaries is an actual infestation unit. Then by a careful study of the infestation within such a unit area we may be able to determine whether or not it follows the course of what we would expect in an actual unit. This is the way we are approaching the problem i n Area A of the conference plan.

In most of our control projects we have assumed that the basin of a tributary watershed, or a well defined plateau, comprising about 10,000 tp 20,000 acres with partial but not complete boundaries of type or topography is a satisfactory unit. From an administrative standpoint at least it is about the best we have been able to find so far. If it is also a practicable infestation unit we are all to the good in our present control policy. If not we will eventually have to change this policy.

A filed study which has considerable bearing upon the infestation unit problem

As a basis for this study suppose that we consider thm a series of small areas approximating the average control unit, all situated in the same general timber belt, and follow closely the course of the infestation in each for a period hf years. In all proablability the infeatation in each will fluctuate from year to year, involving cycles for periodic increase and decrease. If we find that in one unit the infestation is increasing while in others it is decreasing and that there is no uniformity about the course of the infestation throughout the series of units, then we may make two supposition&-

1. That these assumed units are independent and complete and that the infestation in one unit does not affe cta and is not influenced by that in an adjoining unit. The controlling factors operate locally and do not materially extend their operations outside of the division we are considering . Or

2. That the flight habits of the beetles are migratory and that they may be attxacted for several miles at least in their attacks. This would account for the fluctuating differences bewtten the units, and would mean that we have assumed an area that is entirely too small for the infestation unit.

This reduces us to two directly antagonistic conclusions and we are about where we started. Inder these conditions we will not solve the ppobelm although we have gained some very valuable information in regard to the rpogress of the infestation.

On the other hand if the infestation inxthe increases and decreases in about the same porportion throughout the entire series of un its we will again have grounds for at least two assupmtions:

That the units are not complete, but that there is a general equalizing flight of beetles throughout the area, paralled by a corresponding distribution of the natural enemies of the beetles and other controlling factors . This would mean that our infestation unit involves the whole area. However if 50% of the units are undergoing an epidemic increase while the reaminder is decreasing or endemic, we may get at an even more definite basis for asuming the extent of the unit.

If we assume however that the units are complete under these conditions , xxxxxxxx the parallel cycles of increase and decrease throughout the entire series of units, would meaa that the acceleraing and controlling factors are much broader than xxx are generally considered. While the beetles may not migrate from one unit to another to any extent their natural enemies must have some way of distributing themselves generally througout the region, or else the controlling factors are purely climatic .

when the valley narrows down to a canyon at Gold Days

It was for the purpose of determining the epidemic cycle of Dendroctonus infestation and to compare this cycle in a series of assumed units that a study was started by the Pacific slope station. The first consideration was to find an area of sufficient size to be comprehensive and at the same time presenting the necessary specifications of type and infestation. Necessarily such a project must also be limited by the amountly of territory which can be covered acurately for field data by the available forece of men.

From its mouth at Grants Pass to this point

The area selected was timber belt on the western side of the Rogue River, which was worked intensively, with the adjoining areas of the Klamath River and Applegate watersheds as extensive checks. In the Rogue river area we have:

An area of the yellow pine type 36 miles long, and from three to six miles in width.

A pine acerage of 89,000 acres and a volume of 155 million ft

This forms a long narrow belt of timber extending parallel to the main drainiage, northeast to south west.

It is easily divided into a series of 8 arbitrary units of 10,000 acres or less, each formed by a tributary watersehd which cuts transversely across the belt. We have then a chain of contiguous units, all of about the character and extent of our assumed insect control units. One one side of this chain is the open Rogue river valley making a distinct broad break in type. On the opposite side, southwest, is a topographic barrier , the Siskiyous, forming also a considerable break in type throughout most of its extent, by the predominace of fir and hemlock. Thus we have definite and assumed effect boundaries to the infestation on at least two sides. On the contiguous or adjoining side of each unit we have no distinct tyep barriers and can use for boundaries only the intersecting ridges which separate the tributary drainage basins.

One five of these units, sixty percent of the area, every tree was marked numbered and a file record kept. One one unit complete lifehistory records were kept of all available trees. the area was kept under constant observation and as soon as an attacked tree was discovered a record was kept of the develop ment of the brood until emergence.

On the ramaining three units the records of the infestation was kept by extensive methods. Part of the trees were marked and numbered as the a eas were traversed and the reaminder were spotted on the map and an estimate made of the total infestation.

The Applegate area which was studied as a check involves about 200,000 acres, of which less than 50% can be classed as timber land. The Klamath Area includes about 255,000 acres, all more less timbered. An extensive check, spotting of the infested trees and estimte of the toal infestation was made for both the Klamath and Applegate watersheds, annually.

What happened on the Rogue River area was a sudden increase in the infested volume throughout the units. This started with a conspicuous top killing of all yellow pine which was largely traced to the infestation of Ips confusus. An epidemic of D.brevicomis in yellow pine followed which reached its height during the summers of 1915 and 1916 and subsided again in 1917 to a point almost as low as where it started from.

The results for the period from 1914 to 1917 have been summed up as follows:

D.brevicomis was by far the most important species concerned in the epidemic, being responsible for more than 90% of the annual loss.

During this period the brevicomis infestation underwent a distinct cycle covering a period of 4 years, the increase and decrease about equalizing.

During this period the infestation of Ips confusus, as shown by the topkilling of trees declined. The infestation of D.monticolae in sugar pine also declined ,but increased in 1917 at the time that the brevicomis infestation was undergoing its greatest decline.

The brevicomisinfestation ran through about the same cycle throughou the entire project area, being porportionatley uniform on each of the small tributary watersheds which were termed units. The highwatermark of the epidemic occurred in 1915 on some units and in 1916 on others, but we do not find a single case of any unit declining to the low point during these two seasons, or reaching the high point in 1914 or 1917.

During this period there were no fires of any extent on the area and no lumbering operations which could have materially affected the course of the infestation. Apparently the course of the epidemic was normal. Our only inference is that the factors which influence the increase and decrease of ~~epidemics~~ infestation are not confined to small local areas or watersheds, but operate throughout ~~xxxxx~~ a considerable forest region. Apparently what we selected for units did not measure up to the specifications.

In the check areas also on the ~~Klamath~~ and Applegate watersheds we find the same period of cycle. Just what bearing this has on the problem it is difficult to ~~say~~ except that the area in which the infestation followed the same general cycle of increase and decrease was much larger than we anticipated. It may have extended even further than these two check areas but at any rate we had reached the limits of the working capacity of the station force. The only area covered outside of these limits extended to the north and west of the Rogue river. Here throughout a considerable extent of the pine type there was no epidemic of~~xxxxxxxxxxxxxx~~ at all. The infestation remained normal throughout the entire four years.

Late in the fall of 1917 a fire burned over ~~the Mistletoe~~ about 10% of the Mistletoe Unit. The following year, 1918, prooved to be a very bad fire year throughout the region. Another burn occurred on the Mistletoe Unit, and a great deal of the country was burned over in and around the Grant Pass and Apple gate territory just north of the last Rogue River units. The influence of the Mistletoe burn was studied closely, but the study of the other fires, which were much more extensive were entirely beyond the possibiliti es of the station force.

Thus in 1918 we have a new factor entering into the problem, that of extensive fires which without doubt have a very strong attractivr influence for bark beetles. During this year the volume of the infestation on the Mistletoe burn increased over 1100%. These beetles could not have come from ~~the trees~~ the infested trees standing on the burn at the time of the fire. They undoubtedly came from the outside. MJust how far outside

we do not know and have no absolute way of finding out. On the unit outside of the burn the infestation remained at a standstill while on units several miles to the north it increased from 30 to 50%. However the influence of the 1918 fires is a disturbing factor which can only be appreciated after a great deal of intensive study.

This sort of a study represents only one method of approach in working out the infestation unit. Under this method we do not attempt to artifically disturb the infestation in any way. We still have the resource of carrying out artifical experiments which if they do no definitely establish the limits of the infestation unit will give us some indirect data as to the distance of flight by the beetles. For example if it is possible to remove all of the infestation from an assumed unit, by control measures, then it is evident that the infestation must come in from the outside. If we have all of the surrounding infestation difinitely located, then the minimum distance which the beetles would have to fly to get into the cleaned area can be easily determined. Some work of this character has been carried on in the Yosemite National Park.

We have one example of the course of the infestation following a disturbance by control work in the Crane Creek unit of the Yosemite National Park. This unit is located on the western border of the National Park just north of El Portal. It contains about 35000 acres of fine quality of the Yellow pine, sugar pine type. The boudaries however are far from complete their being only one break in type, a very narrow one for ed on the southeast by the Merced canyon. On all other sides the type is continuous with the surrounding country.

The earliest record we have of the infestation on this unit goes back to 1913. In the fall of that year a considerable epidemice of D.brevicomis was located on the area, and as shown by the control work of 1914 an overwintering volume of 100,000 feet existed on the area. A control project was carried out in May and about 46.000 fee of infested timber or % of itsvolume was treated. Thiw work was carried on late in May however when many of the beetles had emerged so it is quite eveident that a much lower volume of infestation was actually treated. Ranger Sullivan who carried on the work estimates that from 30% to 60% of the infestation was actually treated. After looking over the work I doubt very much if it really amounted to that. However the results for the next three years were quite interesting as well as instructive. The next year the the infestation dropped about 20% (volume of annual loss) The next season, 1915 it dropped still lower to 46,000 feet, a decline of % from 1914. In 1916 it dropped continued to decline, dropping down to an annual loss of feet or % reduction. During the examination made in the spring of 1917 several trees were located which could be conveniently treated and it was though best to do so. The number treated amounted to feet or % of the overwintering volume. This apparently resulted disatrously for the next year the infestation increased to 54,000 feet or about %. As contro- work was continued the next year and % of the overwintering volume was tre ated. In 1918 the infestation dropped to 30 feet a reduction of %. none of which is treated. The data for 1919 is of course incomplete.

The infestation of D.monticolae in sugar pine on this unit is relatively much smaller and hardly enough of it was encountered to be significant. It will be noted that it did not follw the same course as

that of D.brevicomis, there by checking with our results of the Rogue River study. In the 1914 control project all of the 1913 overwintering infestation was removed, reinfestation reappeared just the same. in 1914, increased in 1915 and decreased in 1916. and increased in 1917. All of the the overwintering 1917 infestation was removed and in 1918 we have no reinfestation appearing on the area.

All of this dope brings out one point strikingly, with regard to the application of the percentage principle of control. We may apply a certain percentage on a unit of this character during one season and get a certain result. When we apply a similar percentage on another season we may get an entirely different result. This can indicate but one thing; that other factors besides the control work influence the increase or decrease of the infestation. These factor either vary from year to year or else they a considerable number of these factors come in from outside the area. In any case we cannot accept the a unit of this size as an adequate one for the application of control measures no matter whether we apply a control of 50% or 100%.

The most reliable data that we have regarding the flight of D.brevicomis comes from a study of the infestation on the floor of the Yosemite valley proper. This area has been designated as unit 4a. The natiral topographic and type features surrounding this unit furnish conditions which are more nearly ideal for flight experiment purposes than any that have been found to date.

The type is almost ent rely yellow pine. It extends from Easto to West in the fiorm of a long narrow strip, ten miles in lenght and from one to two miles in width. The elevation is fairly consant at 4000 feet. On all sides except the west the type is bounded by high preciptious grainite walls which rise from 3000 to 4000 feet above the valley. In the mountainous country above these canyon walls we get entirely out of the yellow pine type. Only in a few places can any yellow pine or sugar pine befound above the valley floor. The type is composed almost entirely of Jeffrey pine, lodgepole pine and fir.

The unit is also the most accessible and easily studied of any of our areas. The valley floor is traversed by numerous roads and from any point on the canyon rimm the area can be viewed and studied in detail. The demand for fuel onthe part of Park concessionaries maked it poss ble to cut and treat all of the infested as they appear thoughtout the season practically without expense to the Park administration. The cutting of dead and dying trees on the valley floor has been going on for many years. This may have had more or less influence on the amount of the infestation which has existed on the unit during this time. At no time during the past ten years has it been epidemic ,but a relatively low nimber of trees hve been killed annually. Complete volume records of this loss were not kept until 1917, and up until this year we have only a record of the number of trees which have been cut anually since 1913. This shows that from 3 to 18 trees have been attacked annually , most of them being treated but with out any intelligent effort directed toward controlling the infestation.

Finally in 1917 it was decided to direct this work so that all of the infestation in the valley floor would be treated and to determine if possible the source of the reinfestation.which might appear.

This project was undertaken by Mr. Patterson in the spring of 1918 In Aprip of that year he found 10 trees with a volume of 25,000 feetb All of these were treated. Owing to the thoroughness of the cruize and the fact that the control was extended over a period long enough to allow for the late fading of all trees to show colofed foliage it was beleived that all the infestation had been treated. Thatt this was the case is born out by the fact that no more overwintering trees turned up after the control work was completed. During the summer however fourb new trees were attacked making a volumd of 1200 feet. These were treated the first week in September followed by another clone cruise of the valley in which no further infestation would be found.

At this time the infestation should have been free of infestation if it were possible to free it of infestation by the removal of 100% of the visible infestation.

The next spring however it was evident that something had happened after the control work had been completed the early part of September. Thirteen trees had been attacked in the fall making an overwintering gener tion of nearly 30,000 feet. The treatment of these was undertaken in April and May and all of the infestation was treated with the exception of 2 small trees in which the beetles had emerged before they were discovered. However over 90% of the infestation had been removed.

During the spring and summer of 1919 the usual number of summer brood attacks occurred. Including four trap trees which were cut and afterwards infested this attack amounted to 10 trees with a volume of 18000 feet. This has all been treated . We do not know yet what the fall attack of 1919 has amounted to ,but is to be expected that the usual number of attacks will be in evidence by next spring.

While this work was going on in the valley floor something occurred in the Jeffrey pine type that throws more light on character of the flight habits of brevicomis than any other bit of evidence that has been secured in all of out study of this species.

Three miles east of this unit and just north of the Little Yosemite along the Clouds Rest trail some yellow pine occurs in the Jeffrey pine type. There is less than 500 acres and yellow pine consists of a few trees here and there forming but a low percent of the stand. In actual distance it is about four miles from the valley and nearly fifteen miles from the main pine belt to the west. This smalltract is cut off from the main valley by a tremendous topographic barrier, the half dome,clouds rest divide making also a complete break in type. There is only one gap, a very narrow one through the Merced gorge. This small area has been under constant observation since 1913. The infestation has always been found to be the Jeffrey pine beetle in Jeffrey pine. Both in 1914 and again in 1918 projects were carried out to control this infestation. During all this time and up until the summer of 1918 not a single D.brevicomsi tree, either infested or abandoned was ever found in the Little Yosemite area.

While carrying out the control of the Jeffrey pine beetle in June, 1918 Mr.Patterson found a yellow pine fading at the top for about 35 feet. This was felled and the infestation in the top was found to consist entirely of Ips emartinatis, no brevicomis being found as was expected . The remaining green base of this tree was left as a trap to see if the jeffrey pine beetle couldbe attracted to yellow pine. It was hardly considered that brevicomis could bedrawn into this area. Late in the summer however when the trap was examined it was found that it had attracted a perfectly healthy normal belligerent brood of D,brevicomis. Where did it come from? Certainly not from surrounding infestation in the immediate vicinity for none existed. Possibly from the Yosemite

valley floor some four to ten miles away. But the attack on this trap occurred in July at a time when all of the infestation that could be found in the valley had been treated. There is of course the possibility that some of the infestation was missed in the control work and came in to make this attack on the trap. If not we will have to look for its source in the extensive pine belt some fifteen miles away. Let us consider that in any case the beetles had to cross a rugged barrier, cross a complete break in type and rise some 5000 feet in elevation.

What happened in the Little Yosemite area after the beetles emerged from the trap log is of still further significance. A standing yellow pine tree was attacked just about three fourths of amile north and east of the trap log and constituted the only overwintering brevicomis tree on the area. Then in the summer of 1919 following the emergence from overwintering tree, a summer brood tree was attacked within 100 yards of the original trap. Here our narative stops because we do not know what happened in the fall of 1919.

It is difficult to refrain from drawing some conclusions where the limit of the experiment are as complete as theyare in this case. If anyone wishes to contend that D.brevicomis will occasionally make along migratory flight, due to some attractive influence and then for a year or so localize its attacks, and then make another long flight due to some new attraction or to get away from the accumulation of its natural enemies,here is at least one spoke for the wheel.

We have one more experiment of a somilar character in the Yosemite, pretaining to the flight habits of the Jeffrey pine beetle. This was carried out in the snow creek unit, a small basin of Jeffrey pine lying between the head of the Yosemite valley and the Upper Tenaya basin. This unit has exceptionally complete barriers on all sides, the break in type being complete on all sides except in one narrow place. The area involves about 1500 acres of pine type, all Jeffrey pine with a few scattered yellow pine trees at the lower edge. This unit also has been under continual observation since 1915 and the infestation has been entirely an endemic one of the Jeffrey pine beetle. The amount of loss has been constant, averaging from four to six trees annually. It was decided to treat all of the infestation that could be found in the spring of 1918 with a view of determing whether the removal of an endemic infestation would effectively rid an area of this size of the infestation. In June 6 large jeffrey pines were treated, all being trees of the overwintering generation. Subsequent examinations were made during the summer to see if any of the overwintering trees might have been missed because of green foliage but none were found. In the spring of 1919 a recruise of the area revealed the fact that four new trees had been attacked in 1918 following the control work. In view of the results which had been secured from the other units this amount of reinfestation was not at all surprising.

Still further data regarding flight records of D.brevicomis are available from the Sequoia National Park. The yellow pine sugar pine type of this region terminates abruptly at its lower elevation. Usually below the 5000 foot contour. Below this level we have only oak and brousb areas while above it the pine extends to 7000 feet. At Colony mill point on the southern boundary of the pine belt, the type extends out along a narrow ridge for nearly a mile forming a distinct peninsula in

During the season of 1918 while the control work was underway at Colony mill, it was noted the pine on this pint was practically free of infestation. No breviconis broods either in standing trees or down logscould be found although several old abandoned trees were found on the point. It was decided to cut two trap trees, one at the extreme southern end of the point, the other about halfway between the first and themain pine belt and see if breviconis beetles would be attracted to them from infested trees which were located to the north. The nearest infested trees from which the beetles could possibly come consisted of a group of three trees which were too nearly abandoned at the time of control work to warrant treatment. This group was approximately three fourths of a mile from the neartest trap and nearly one and one fourth mile from the farthest. Both trap trees were cut on May 22nd. Both trees were attacked by breviconis early in June, the amount of the infestation being about equal in both logs. The broods which developed in both logs were treatedbefore they emerged. However a lightening storm took a hadn in the experiment, struck two trees, started a small fire with the result that four more trees were attacked on the point during the summer. With all the control work that it has been possible to do since then it has been impossible to free this point of infestation..

This evidence all has a bearing which indicates that the beetles may under certain conditons fly a considerable distance. On the other hand it is possible to bring up considerable contradictorary evidence, by showing that where an infested tree stands one year another is pretty certain to be found the next season, indicating a very short distance of flight. But we must account for the much longer distances which beetles must fly to get into new territory. If the dyktance of this flight amounts to several miles, and our evidence indicates that it does, then we have not yet found such a thing as a complete control unit in actual practice.

Forest Insect

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